Final Report

submitted to the

Office of Naval Research

Grant No:	N00014-92-J-1673
R&T Code:	413z004srp01
Project Title:	Molten Salt Techniques for Reproducible Excess Heat
Project Period:	June 1992 to December 1993
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January 5, 1994

Summary of Major Accomplishments:

1. Experimental Results:

- Electrochemical characterization of Ni electrode system in the hydride-containing molten salts.

  Our earlier experiments using Pd anode, Al cathode and D-based molten salt electrolytes showed large temperature excursions during high-current charging of Pd. Reproducing this effect was difficult due to insufficient understanding of the electrochemical behavior in the system. Ni was chosen as a model anode material for the study of such a behavior due to its inertness in the molten salt environment. Cyclic voltammetry was used to investigate the electrochemical reactions in the molten salt system. We found that hydrogen evolution was the major reaction on the Ni anode. This reaction is sensitive to impurity present in the melt. Si was found to retard the hydrogen evolution reaction substantially, suggesting that it can be used as an inhibitor for hydrogen loading. The effect of LiH concentration in the melt was also studied. A terminal saturation concentration was determined to be about 5-6%.

- Calorimetry measurements of anomalous temperature excursion in the electrolysis of the Ni-H-based molten salt systems.

  Some anomalous temperature and thus excess power excursions were detected in the electrolysis of an Al | H-based molten salt electrolyte | Ni cell at different current densities. This excess power cannot be explained by the enthalpies associated with various possible reactions in the cell. The amount compared to possible IR loss heat rate was quite significant, about one order of magnitude higher. However, the amount was only about 30% to the input electrochemical power and a small fraction of the total input power that includes both the electrochemical power and the dc power supplied to the external furnace. The origin of this effect is still unknown, nor is the nuclear aspect. It is, however, unlikely to be an artifact due to random noise or storage mechanism.

2. Overview and Conclusion

The excess heat generation in molten salt systems are progressing well through the increasing understanding of electrochemical behavior of the cell and the availability of a variety of electrode materials used in the cell. Several issues are still open for improvements: the control of the cell behavior, the integrity of anode materials, the role of impurities in excess heat generation, and the threshold loading at elevated temperatures – just to name a few. We are more confident than ever that we can repeat the excess heat phenomenon more frequently, if funds are available to support this effort.

From numerous reports in the recent 4th International Conference on Cold Fusion, it seems clear to me that D-D fusion was not the origin of the anomalous effects that we have observed in this field. The excess heat effect would be difficult to attribute to any chemical origins. If nuclear origins were the cause of anomalies, many possible reactions are then prevailing in various temperature ranges, generating an array of signatures in both heat and nuclear products, not conforming to any single mechanism. This is a tremendously hard task for the experimentalists and theorists to verify each and every of them. This scenario also prohibits a consensus to what have happened to each positive experiments.

3. Human Resource and Personnel:

Dr. Yi Ding, a postdoctoral research associate
Professor Bruce E. Liebert, co-investigator

4. List of Publications and Technical Reports:

1. [Tech. Report #1, submitted]
   B. Y. Liaw. "Hydride-Containing Molten Salts and Their Technology Implications," in *Proceedings for the European Workshop on Electrochemical Technology of Molten Salts*, C. A. C. Sequeira and G. S. Picard, ed., European Workshop on Electrochemical Technology of Molten Salts, Sintra, Portugal, March 14-17, 1993, Trans Tech Publications, in press.

2. [Tech. Report #2, submitted]
   Y. Ding and B. Y. Liaw. "Electrochemical Characterization of Ni in Hydride-Containing Molten Salts," presented in the 9th International Conference on Solid State Ionics, the Hague, Netherlands, September 12-17, 1993; to be published in Solid State Ionics.

3. [Tech. Report #3, to be submitted]
   Y. Ding, B. E. Liebert, and B. Y. Liaw. "Electrochemical Characterization of Ni in LiH-Containing Eutectic KCl-LiCl Melts: Cyclic Voltammetry Studies," J. Electrochem. Soc., (to be submitted).

4. [Progress Report submitted on October 20, 1993]
   "Status Report on Molten Salt Experiments for Anomalous Heat in the Cell: Al | LiH(saturated), LiCl-KCl Eutectic | Ni."

5. [Tech. Report #4, submitted]
   B. Y. Liaw and Y. Ding. "Charging Hydrogen into Ni in Hydride-Containing Molten Salts," to be published in the Proceedings of the 4th International Conference on Cold Fusion, December 6-9, 1993, Lahaina, Maui, HI, M. C. H. McKubre and T. Passell, ed., Electric Power Research Institute, CA.

6. [Tech. Report #5, to be submitted]
B. Y. Liaw. "Some Thermodynamic Aspects Related to Charging Hydrogen Species into Metal Lattice," presented in the 4th International Conference on *Cold Fusion, December 6-9, 1993, Lahaina, Maui, HI.*

7. [Tech. Report #6, to be submitted]
B. Y. Liaw. "Molten Salt Techniques for Excess Heat Production and the Loading Issue," submitted to the Minsk Cold Fusion Conference, May 1994, Minsk, Belarus.